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All 4 memos to Suz. Forward to Aubrey, Chris & Bill; then discuss w them. (Joan & Daryl too.)

To: Scott Brown, U.S.E.P.A., Helena, MT.

From: Douglas J. Dollhopf

Cc: Dennis Neuman

Re: **Comparison Of Sector Closure Areas And Kriged Isopleth Lines For The 500 mg/kg And 1000 mg/kg Total Soil Lead Concentrations**

Objective

•For the East Helena smelter emission project area, evaluate whether both sector closure statistics and kriged isopleth lines delineated similar areas where total soil lead exceeded 1000 mg/kg and 500 mg/kg.

Support Documents and Sector Closure Criterion

During the remedial investigation, 157 soil samples were collected (0-4 inch depth)across the entire Helena Valley and geostatistics, variograms, and kriged maps were used to delineate the distribution of total soil lead (CH2M Hill 1987). Subsequently, yard sampling in East Helena resulted in collection of hundreds of soil samples (0-1 inch depth) and a sector statistics method was used to identify areas where 1000 mg/kg total lead was exceeded, which was the criterion for yard removal (Hydrometrics, Inc. 1995). When either i) data within the outer most portion of a sector had an upper 95 % confidence limit less than 1000 mg/kg total lead, or ii) no more residential yards were present in the sector, then the sector was closed and yard sampling ceased. A synopsis of sector closure statistics is presented in Table 1.

Comparison Between Sector Closure Statistics And The Kriged Map For Areas Exceeding 1000 mg/kg Total Soil Lead

•Sector 1. This closure sector was located approximately 0.6 miles from the smelter stack. The closure sector had a mean total soil lead content of 613 mg/kg and the upper 95 % confidence

Table 1. Sector closure data as reported by Hydrometrics, Inc. (1995). define

Sector	Soil Samples	mg/kg Pb				
		Mean	Maximum	Minimum	Upper 95 % Confidence Limit 2-Tailed Test	Upper 95 % Confidence Limit 1-Tailed Test[1]
1	70	613	2071	163	1303	1192
2	49	382	1256	69	897	815
3	72	847	2339	80	2015	1828
4	86	358	935	85	739	678
5	113	514	1404	116	1036	952
6	132	477	3908	94	1269	1142
7	65	526	1421	145	1038	956
8	16	278	646	109	567	516

.51 .47 .46 .53 .54 .42 .55 .54

[1] The one tailed test was used by Hydrometrics to make sector closure decisions.

limit (one tailed test) was 1192 mg/kg. Although the upper 95 % confidence limit was not less than the criterion for closure, i.e. 1000 mg/kg total lead, the sector was closed presumably because there were no more residential areas remaining within the outer reaches of this sector. In comparison, the isopleth line (2.6 $\log_{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 0.3 miles from the smelter stack. 613 ÷ 1192 = 0.51

•Sector 2. This closure sector was located approximately 0.6 miles from the smelter stack. The closure sector had a mean total soil lead content of 382 mg/kg and the upper 95 % confidence limit (one tailed test) was 815 mg/kg. In comparison, the isopleth line (2.6 $\log_{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 0.3 miles from the smelter stack. 382 ÷ 815 = 0.47

•Sector 3. This closure sector was located approximately 0.6 miles from the smelter stack. The closure sector had a mean total soil lead content of 847 mg/kg and the upper 95 % confidence limit (one tailed test) was 1828 mg/kg. Although the upper 95 % confidence limit was not less than the criterion for closure, i.e. 1000 mg/kg total lead, the sector was closed presumably because there were no more residential areas remaining within the outer reaches of this sector. In comparison, the isopleth line (2.6 $\log^{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging

847 ÷ 1828 = 0.46

methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 0.4 miles from the smelter stack.

•Sector 4. This closure sector was located approximately 1.5 miles from the smelter stack. The closure sector had a mean total soil lead content of 358 mg/kg and the upper 95 % confidence limit (one tailed test) was 678 mg/kg. In comparison, the isopleth line (2.6 $\log^{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 1.3 miles from the smelter stack.

$358 \div 678 = 0.53$

•Sector 5. This closure sector was located approximately 1.3 miles from the smelter stack. The closure sector had a mean total soil lead content of 514 mg/kg and the upper 95 % confidence limit (one tailed test) was 952 mg/kg. In comparison, the isopleth line (2.6 $\log^{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 1.3 miles from the smelter stack.

$514 \div 952 = 0.54$

•Sector 6. This closure sector was located approximately 0.8 miles from the smelter stack. The closure sector had a mean total soil lead content of 477 mg/kg and the upper 95 % confidence limit (one tailed test) was 1142 mg/kg. Although the upper 95 % confidence limit was not less than the criterion for closure, i.e. 1000 mg/kg total lead, the sector was closed presumably because there were no more residential areas remaining within the outer reaches of this sector. In comparison, the isopleth line (2.6 $\log^{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 1.1 miles from the smelter stack. $477 \div 1142 = 0.42$

•Sector 7. This closure sector was located approximately 1.0 miles from the smelter stack. The closure sector had a mean total soil lead content of 526 mg/kg and the upper 95 % confidence limit (one tailed test) was 956 mg/kg. In comparison, the isopleth line (2.6 $\log^{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 1.0 miles from the smelter stack.

$526 \div 956 = 0.55$

•Sector 8. This closure sector was located approximately 1.1 miles from the smelter stack. The closure sector had a mean total soil lead content of 278 mg/kg and the upper 95 % confidence limit (one tailed test) was 516 mg/kg. In comparison, the isopleth line (2.6 $\log^{10}$, Figure 3.5 CH2M Hill 1987) produced by kriging methods, that identified where there was less than a 5 % chance that total soil lead would exceed 1000 mg/kg, was approximately 1.2 miles from the smelter stack.

$278 \div 516 = 0.54$

In summary, both sector closure statistics (Hydrometrics 1995) and kriged map (CH2M Hill 1987) results indicated there was less than a 5 % probability that total soil lead would exceed

1000 mg/kg at distances greater than approximately 1.5 miles from the smelter (Table 2). For the 8 sectors, the estimated mean closure distance was 0.94 miles, and the kriged isopleth line had a mean distance of 0.86 miles from the smelter. Therefore, the two methods for evaluating distribution of total soil lead around the ASARCO smelter complemented each other.

Table 2. Comparison of distances from the ASARCO smelter where there was less than a 5 % probability that total soil lead exceeded 1000 mg/kg using the sector closure method and the kriged map method.

Statistical Method	Approximate Distance (miles) From Smelter Where There Was Less Than 5 % Probability That Total Soil Lead Exceeded 1000 mg/kg								
	Sector 1	Sector 2	Sector 3	Sector 4	Sector 5	Sector 6	Sector 7	Sector 8	Mean
Sector Closure Statistic	0.6	0.6	0.6	1.5	1.3	0.8	1.0	1.1	**0.94**
Kriged Map	0.3	0.3	0.4	1.3	1.3	1.1	1.0	1.2	**0.86**

Comparison Between Sector Closure Statistics And The Kriged Map For Areas Exceeding 500 mg/kg Total Soil Lead

The sector closure rule was based on a human health risk based concentration of 1000 mg/kg total soil lead. If the human risk based concentration were decreased to 500 mg/kg total soil lead, yard sampling and removal procedures would need to be extended further out from the smelter in each sector. The distance that these sectors would be extended outward can be estimated from Figures 3.4 and 3.5 (CH2M Hill 1987) and the following calculation.

•On Figure 3.5, the area encompassed by the 2.70 ($\log_{10}$) isopleth line is composed almost entirely of soils having greater than 500 mg/kg total lead. Total soil lead concentrations greater than 500 mg/kg will be encountered outside the 2.70 ($\log_{10}$) isopleth line, but there is less than a 5 % probability of locating such soil concentrations outside the 2.30 ($\log_{10}$) isopleth line on Figure 3.5. The 2.30 ($\log_{10}$) isopleth line equates to a total soil lead concentration of 200 mg/kg. The calculation in support of this finding follows.

•One tailed t-value @ n = 157 @ 95 % confidence = 1.6448
As shown on Figure 3.4, a standard error of 0.24 is appropriate to use for the soil area containing greater than 500 mg/kg Pb.

$$2.30 + (0.24)(1.6448) = 2.7$$
$$10^{2.7} = 500 \text{ mg/kg Pb}$$

This isopleth line 2.30 ($\log_{10}$) in Figure 3.5 (CH2M Hill 1987) estimates the area where there is less than a 5 % probability that total soil lead will exceed 500 mg/kg. This boundary includes an

area of 5893 acres. If the human risk based concentration were decreased to 500 mg/kg total soil lead, the number of new residential yards that would need to be soil sampled approaches that previously completed with the 1000 mg/kg criterion.

sampled, not necessarily removed

References Cited

CH2M Hill. 1987. Remedial investigation of soils, vegetation and livestock, East Helena site (ASARCO), MT. Prepared for Environmental Protection Agency, Helena, MT.

Hydrometrics, Inc. 1995. East Helena residential soils sector sampling summary. Prepared for ASARCO, Inc, Helena, MT.